Indian Head Division
Naval Surface Warfare Center
Indian Head, MD 20640-5035

IHTR 1862
29 February 1996

VELOCITY VARIATION OVER TIME FOR NACO ROUNDS

Susan T. Peters

REPORT DOCUMENTATION PAGE

Form Approved
QMB No. 0704-0188

1. AGENCY USE ONLY (*Leave Blank*)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	29 February 1996	Final Report

4. TITLE AND SUBTITLE

VELOCITY VARIATION OVER TIME FOR NACO ROUNDS

5. FUNDING NUMBERS

PIP 95 ACAF05

6. AUTHOR(S)

Susan T. Peters

7. PERFORMING ORGANIZATIONS NAME(S) AND ADDRESS(ES)

Indian Head Division
Naval Surface Warfare Center
Indian Head, MD 20640-5035

8. PERFORMING ORGANIZATION REPORT NUMBER

IHTR 1862

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Crane Division
Naval Surface Warfare Center
Code PM413, L. Massa
Crane IN 47522-5001

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (*Maximum 200 words*)

Firing records covering the master powder shots associated with over 15 years worth of 5-in powder proof firings are examined for velocity degradation over time. None is found, though an increase in velocity is seen. An explanation for this behavior is offered.

14. SUBJECT TERMS

Gun Ammunition, Ballistic Performance

15. NUMBER OF PAGES

14

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	SAR

FOREWORD

The work reported herein was performed at the Indian Head Division, Naval Surface Warfare Center, Indian Head, MD as part of our role as design agent for major caliber gun ammunition propelling charges. The sponsor, Mr. Larry Massa. Code PM413 off Crane Division, Naval Surface Warfare Center, funded the work through PIP 95ACAF05.

T. Craig Smith
Manager, Gun Systems Branch

Approved and released by:

William Yeckley
Director, Surface Weapons Division

CONTENTS

FIGURES

INTRODUCTION

For quite some time, the only surveillance performed on Navy propelling charges is the safety surveillance program associated with the long-term stability of the propellant. No check on the performance of the charges is routinely performed. This led to the question of whether performance of the rounds, as measured by their initial velocity, was changing over time. If such changes were taking place and could be predicted, then a correction could be applied in the fire control solution to compensate for such changes.

It was the objective of this study to determine the need for performance surveillance of Navy gun propelling charges, then if necessary, assess the impact of increasing age on the ballistic performance of the rounds. Finally, compensatory corrections to the fire control solution were to be developed if the need were apparent.

APPROACH

The study was funded as PIP95ACAF05. The approach used was to examine the records from powder proof firings over as long a period as the same master powder was in use. Data for master powder shots for each lot fired were compiled and compared to ascertain whether any loss in velocity was noted. Only 5-in propellant (Naco) was studied since there have been only 17 lots of M6+2 made and proofed for the 76-mm system and this seemed too small a sample to develop reliable trends. The velocities for all the shots for a given barrel (Remember that four barrels are used for proofing 5-in powder.) were plotted against the age of the powder as measured from the powder's proofing, then a line was fit to the data as shown in Figures 1 through 4. In all four cases, the velocity rose over time, though the degree varied by barrel. The initial velocity for each gun barrel (which had seen proof firings only) also varied.

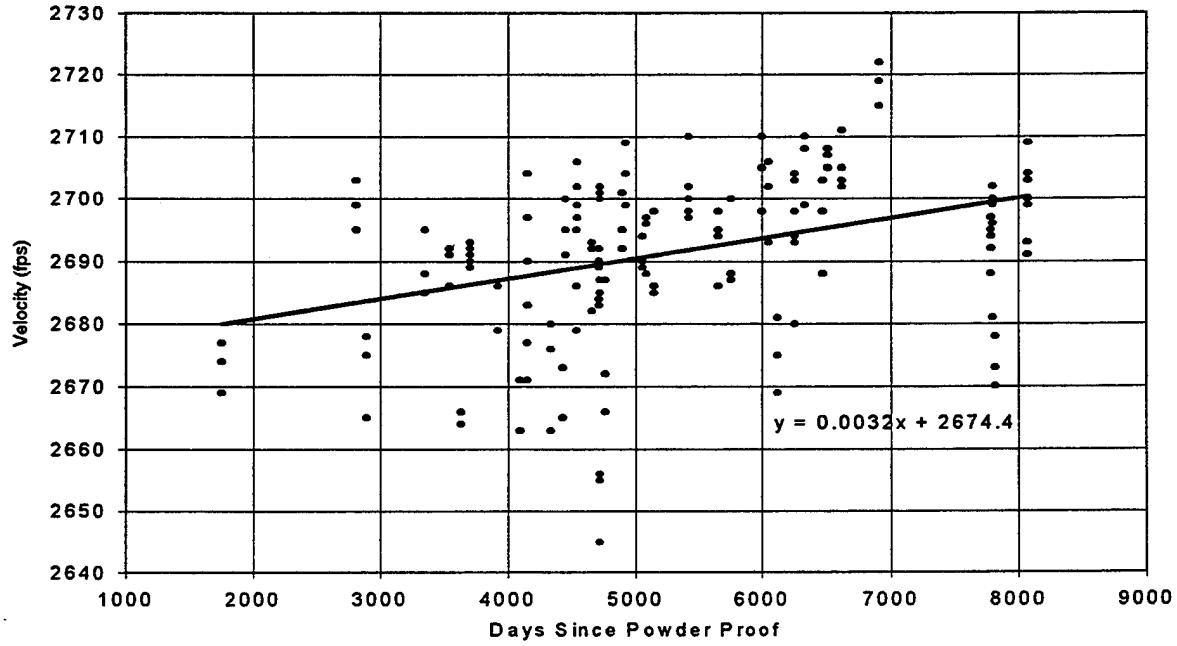

Figure 1. Velocity Variation Over Time From Barrel 16973

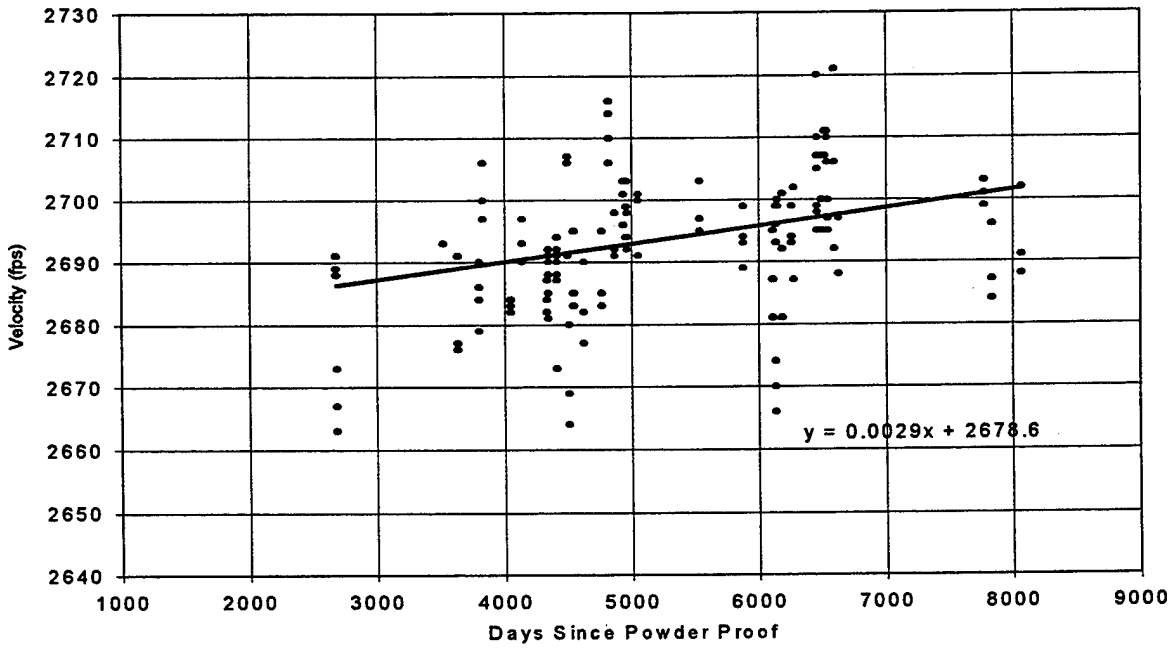

Figure 2. Velocity Variation Over Time From Barrel 16974

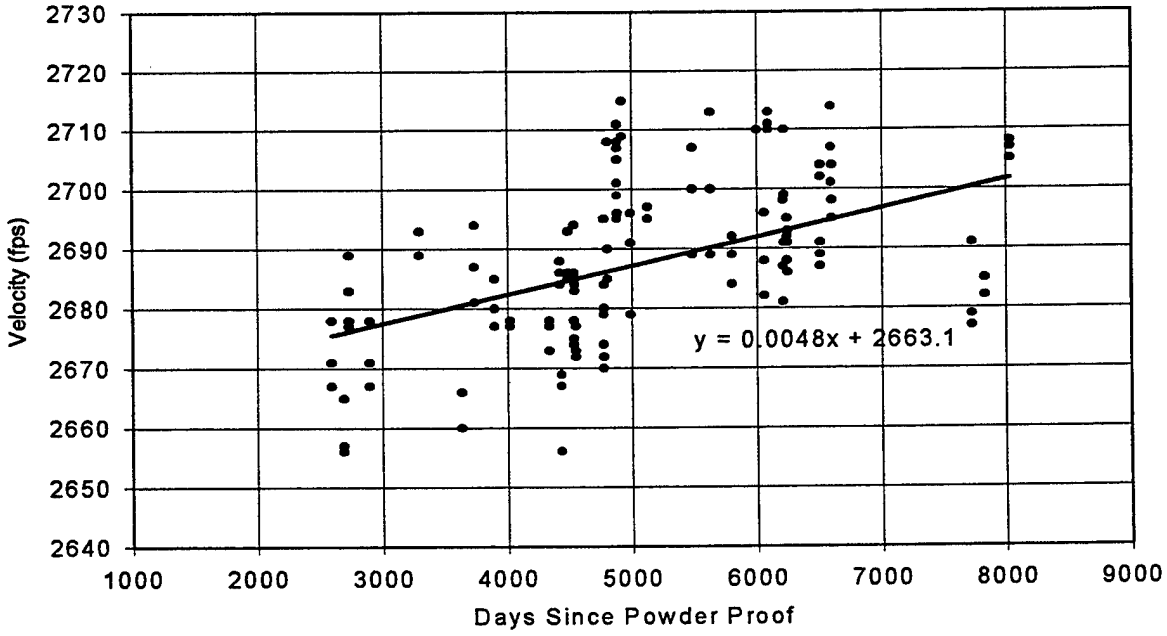

Figure 3. Velocity Variation Over Time From Barrel 16979

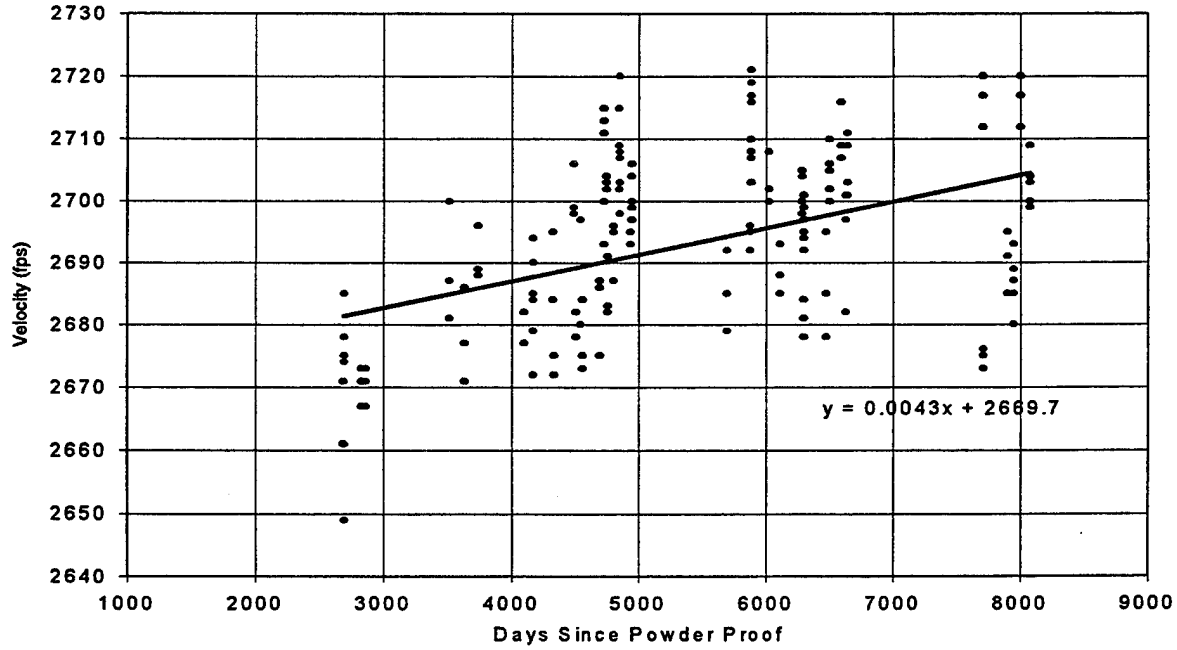

Figure 4. Velocity Variation Over Time From Barrel 16981

DISCUSSION

The variation in velocity from barrel to barrel is fairly significant, giving a standard deviation of 5.5 ft/s for the extrapolated initial velocity. The range table for 5-in, 54-caliber guns firing Mk 41 and Mk 64 projectiles, SW323-AF-ORD-010,indicates that a new barrel should fire at 2683 feet per second. The four powder proof barrels examined here would have yielded a mean velocity of 2679 ft/s with a range of 2674 to ft/s. Given the identical firing history for these barrels, we can only expect the variability in the fleet to be greater since those barrels see differing firing histories, differing operating environments and differing attention to proper maintenance. In light of these results, treatment of the portion of the total error budget assigned to gun barrel variation may need to be re-examined. Interestingly, after approximately a thousand rounds, all four barrels are now firing at approximately the same velocity of 2702 ft/s.

While the data clearly show that no *decrease* in velocity is seen over time, the increase could be cause for concern. New barrels initially shoot at a velocity higher than 2650 ft/s, but steadily lose velocity as they wear. Of the data taken in the course of proof testing, only the projectile seating distance gauge readings (PSDG) give a measure of the barrel's wear state. Unfortunately PSDG readings did not provide a consistent picture of the wear state of the barrels, except to show that the barrels are essentially unworn, yielding readings between 35.3 and 35.4 in. (It is not until the PSDG reads 35.7 in that the velocity falls below the nominal "new" gun velocity of ft/s.) Many methods have been developed to account for velocity loss due to barrel erosion, but all predict some steady decline in velocity.

Solvent loss from the propellant could account for increasing velocity (by removing inert components thereby increasing the net propellant energy), but the powder is stored in air-tight metal cans until just prior to loading, so that explanation would not seem to apply. The normal aging of the powder would result in lower energy, and, so, lower velocity.

Conversation with Paul Conroy of the Army Research Laboratory revealed that small arms enthusiasts are familiar with a process called "lapping", in which single shots are alternated with cleaning to polish the surface of the bore, thereby achieving lower bore resistance in the downbore portion of the interior ballistic cycle, somewhat higher velocity, and, more importantly, lower velocity dispersion. For powder proof barrels, the barrel is given a quick swiping, then coated with oil between powder lots. While not a thorough cleaning, this procedure may be adequate to remove the residue left by the previous firings Given the relatively low numbers of shots fired in a slow mode for powder proofing, the clean, cool nature of the Naco powder, and the frequent cleaning given these barrels, the increased velocity seen over time could be the result of these barrels being "lapped". To date, this is the only theory which seems to explain an *increase* in velocity over time. The fact that all four barrels have approached the same velocity lends credence to this theory. It would appear that the minor manufacturing differences between the four barrels, apparent in their early, differing firing velocities, have been "lapped" away, leaving them much more similar in their ballistics.

CONCLUSION

Over a twenty year period, master powder index 11041 has shown an increase in achieved velocity, averaged over four gun barrels, of approximately 20 ft/s. With the process of lapping to explain the increase in velocity which the rounds exhibited over a number of years, we can be comfortable in stating that the performance of loaded rounds is not expected to change appreciably over time and that no correction need be applied in the fire control solution for older rounds. This assumes that propelling charges have been stored properly throughout their lifetimes (in accordance with OP4 and OP5), having experienced no unacceptable storage environment excursions.

DISTRIBUTION

ADMINISTRATOR
DEFENSE TECH INFO CTR
ATTN DTIC-OCC
8725 JOHN J KINGMAN RD, SUITE 0944
FT BELVOIR VA 22060-6218 1

COMMANDER
NAVAL SEA SYSTEMS COMMAND
ATTN SEA 91WM R BOWEN
WASHINGTON DC 20362-5101 1

COMMANDER
NAV SURF WARFARE CENTER
CRANE DIVISION
CODE PMS 413
CRANE IN 47522 1

COMMANDER
NAV SURF WARFARE CENTER
CRANE DIVISION
CODE PM4 (BEATTY)
CRANE IN 47522 1

DIRECTOR
ARMY RESEARCH LABORATORY
TECHNICAL LIBRARY
APG MD 21005-5066 1

DIRECTOR
ARMY RESEARCH LABORATORY
AMSRL-WT-PD (P CONROY)
APG MD 21005-5066 1

COMMANDER
US ARMY ARMAMENT RESEARCH
DEVELOPMENT & ENGINEERING CTR
SMCAR-AEE-BR (D DOWNS)
INFORMATION RESEARCH CENTER
PICATINNY ARSENAL NJ 07806-5000 1

COMMANDER
US ARMY ARMAMENT RESEARCH
DEVELOPMENT & ENGINEERING CTR
AMSTA-AR-IMC BLDG 59
INFORMATION RESEARCH CENTER
PICATINNY ARSENAL NJ 07806-5000 1

HERCULES INC
RADFORD ARMY AMMUNITION PLANT
ATTN D WORRELL
RADFORD VA 24141-0299 1

VERITAY TECHNOLOGY
ATTN E FISHER
4845 MILLERSPORT HIGHWAY
EAST AMHERST NY 14501-0305 1

DARMENG-N
CP2-6-08
CAMPBELL PARK
CANBERRA ACT 2600
AUSTRALIA 1

Internal:

102	1
3220	1
6210	5
8510	2
8530	3